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(54) Method and apparatus for grading tablets

(57) Tablets 3 are produced by press forming in dies in a rotary die plate 1 passing beneath a pressing station 2. Downstream of the pressing station 2, there are an accepted tablet outlet 5 and a rejected tablet outlet 6, with a vertically movable guide wall 7 determining which path each tablet will follow. The press force pertaining to each individual pressing operation is measured, and the guide wall 7 is actuated in dependence on the measured individual press force, and is also controlled in dependence on the rotational speed of the die plate 1 and on the position of a die relative to the guide wall 7.

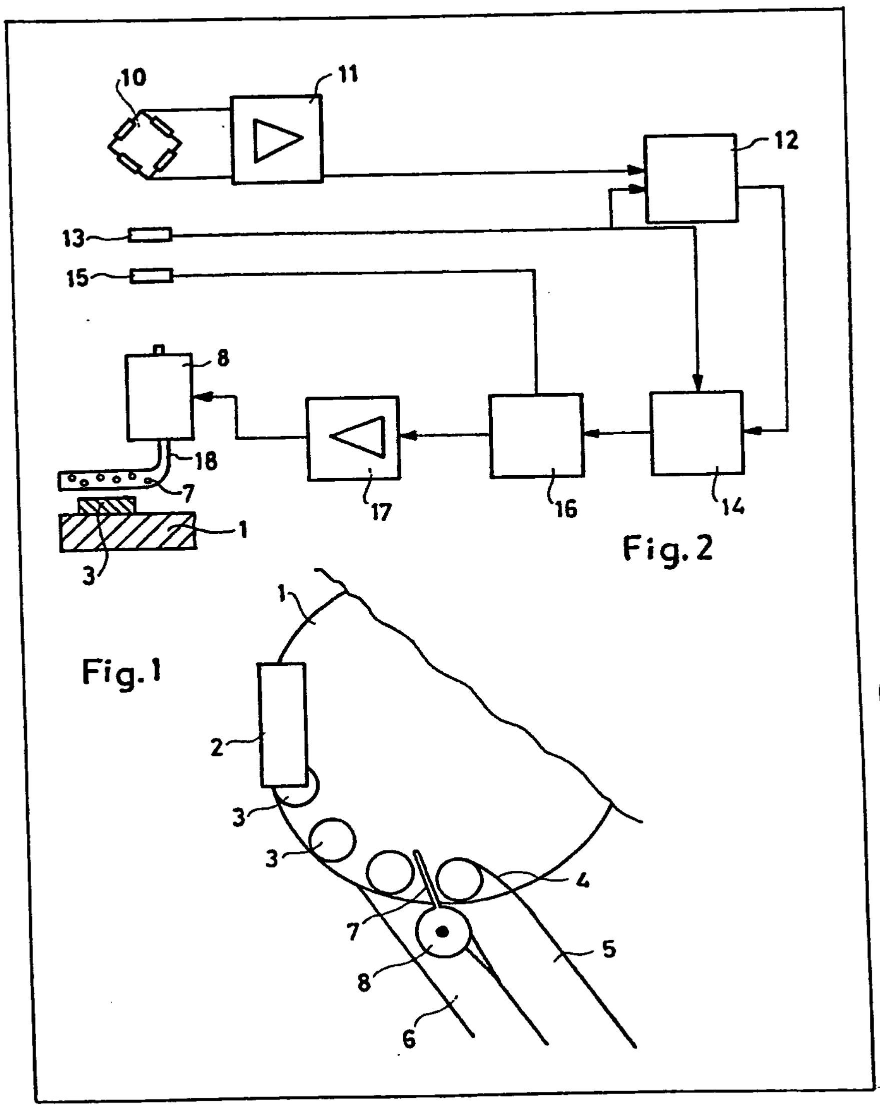

Fig. 2

Fig. 1

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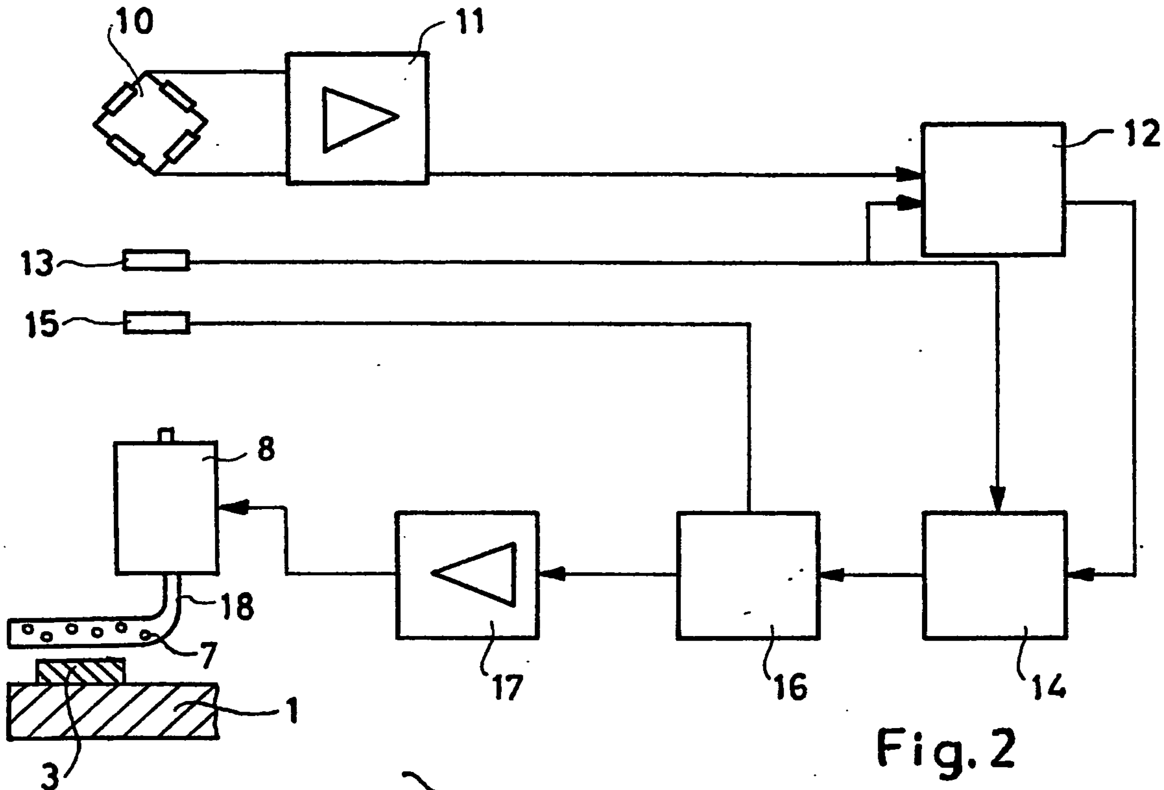


Fig. 2

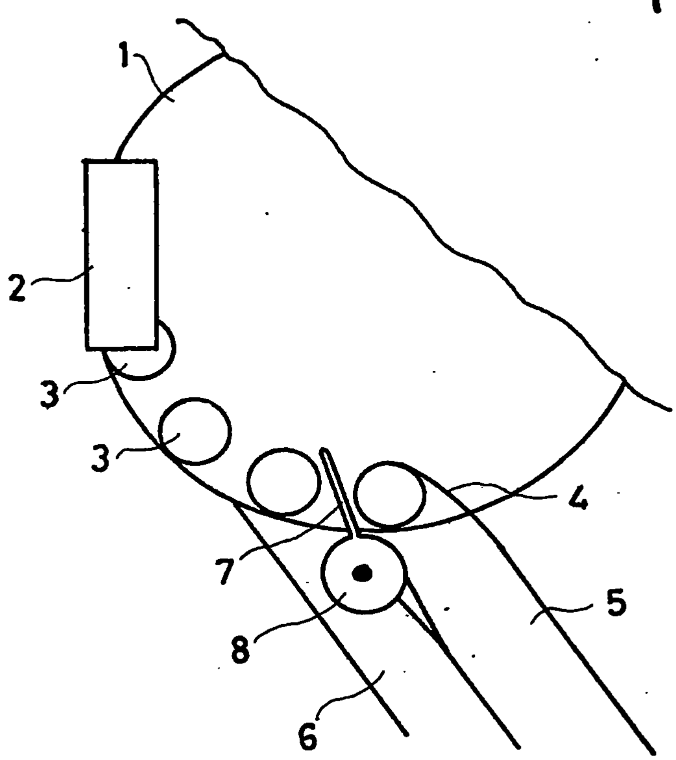


Fig. 1

Fig. 3

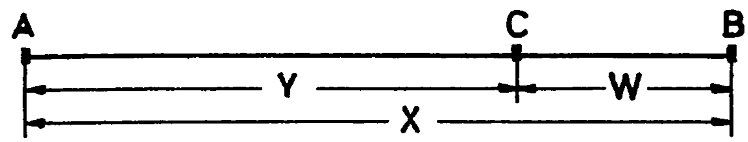


Fig. 4

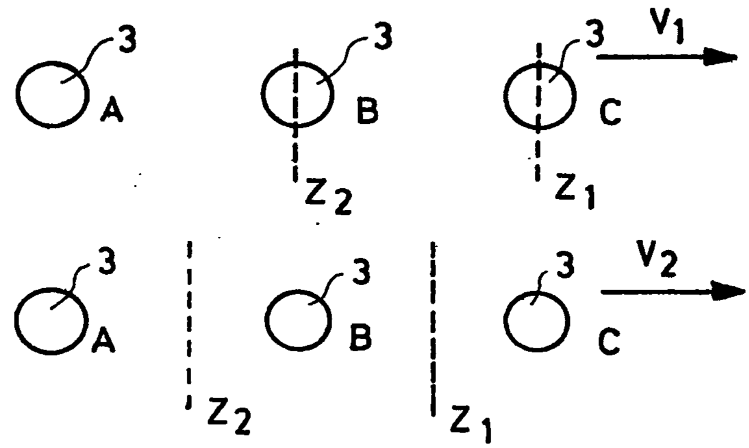
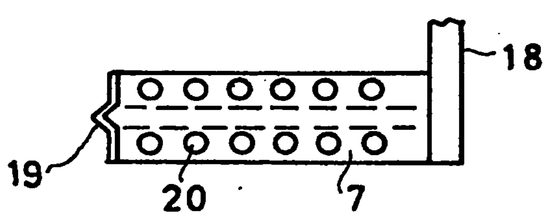


Fig. 5



SPECIFICATION

Method and apparatus for grading tablets after the production thereof in a tablet forming machine

The invention relates to a method of grading tablets after the production thereof by press forming in dies of a tablet forming machine, by measurement of the individual press forces, in which an ejector station, disposed downstream of the press station, is actuated by control *via* a punch proximity switch. The invention also relates to apparatus for performing the method.

Tablets are produced in known tablet forming machines in dies of a rotating die plate in which the powder is compressed by punches. To ensure a specific quality for all tablets the press forces applied during the production of the individual tablets are constantly measured and compared with set points. The tablet must be rejected if the measured individual press force of a tablet is above or below two set point limits. To this end an ejector device is used which is disposed downstream of the press station and is actuated by the approach of the affected poor tablet. The ejector device is controlled by a known device by means of signals which are entered into a shift register by the press force monitoring unit and by a first punch proximity switch.

Known methods and apparatus suffer from the disadvantage of the so-called grading frequency being too low to be suitable for high speed machines, where grading frequency refers to the number of grading operations possible in unit time, for example in one second. This is due to the fact, more particularly, that there is no automatic shift of the trigger time for the grading element in dependence on the tablet press forming rate.

Known devices for grading operate at a grading frequency of up to 30 Hz, i.e. 30 possible operating cycles per second. However, high speed tablet forming machines of later construction are already able to produce approximately 80 tablets/second.

It is the object of the invention to disclose a method and apparatus for grading tablets, but allowing substantially higher grading frequencies to be obtained by comparison to known devices. According to the invention the ejector device is additionally controlled *via* a second punch proximity switch and an electronic time processing element in dependence, with respect to time, on therotational speed of the die plate and on the position of a die relative to the ejector device. the invention proceeds from the use of a guide wall, functioning as deflector plate for a tablet which is to be rejected and is advantageously lowered from above between two successive circulating tablets and after deflection of the detected poor tablet is again raised into its starting position, actuation being performed by an electromagnet. The lifting magnet is triggered with a time shift in dependence on the rotational speed of the die plate or the press forming frequency or the rotational speed. A trigger time, at which the guide plate is lowered when the advancing tablet is still below the guide wall, is selected if the rotational speed is relatively high. However, if the die plate operates at a lower speed, the lifting magnet for deflecting the next tablet is taken into operation at a time at which the advancing tablet has already passed beneath the guide wall. This prevents the advancing tablet being damaged by the action of the guide wall in the case of a slow rotational speed while on the other hand the guide wall assumes the position of its bottom dead centre before the poor tablet passes thereagainst in cases of high rotational speed or high press forming frequency.

With the invention these advantages can be achieved by virtue of the pulse, which is triggered by measurement of the poor tablet, and is derived from the press force monitoring unit, constructed as electronic logic module and connected downstream of the shift register, is not directly utilized for driving the lifting magnet but is fed into a time processing element which transfers the signal only after a delay which depends on the press forming frequency and is signalled to the element by a second proximity switch. Furthermore, the inertia time, required by the ejector device for its operation, is allowed for in the time procesing element. To minimize the inertia time it is convenient to minimize the moving masses accompanying the operation of the ejector device.

It was therefore found to be convenient for the guide wall to consist of titanium. Providing the guide wall with apertures also contributes to reducing the mass. An adequate stiffness can be obtained by the arrangement of one or more beads.

the guide wall is connected to the lifting magnets more particularly by a piston rod which is connected to the armatures supported in the lifting magnet.

The ejector device can be controlled *via* the electronic time processing element so that at low rotational speeds of the die plate or low press forming frequencies the guide wall remains or dwells longer in its lower position at the bottom dead centre then at high rotational speeds so that the time processing element not only adapts the timing in the operations of lifting magnet in dependence on the rotational speed but also controls the duration of one operating cycle of the ejector device, which said cycle at least comprises lowering and raising of the guide wall and can also include dwelling of the guide wall in the lowered position.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a partial section of a tablet forming machine as a plan view;

Figure 2 shows the ejector device with measuring devices and circuits in a diagrammatic view;

Figure 3 is a plan of the ejector operation with respect to time;

Figure 4 shows two differently timed ejector operations in diagrammatic form; and

Figure 5 is a side view of the guide wall.

Figure 1 is a plan view of a die plate 1 which passes beneath a press forming station 2. The tablets 3 are pressed with punches in dies in the region of the press forming station 2. The press forces applied for the production of each tablet 3 are measured. If the press forces do not reveal any defects in the tablets the latter are diverted from the die plate 1 *via* the stripper 4 into the duct 5. Faulty or poor tablets are diverted into the "poor" duct 6. To do this, a guide wall 7, connected to a lifting magnet 8, is brought into action. By means of the lifting magnet 8 the guide wall 7 is guided between two successive tablets 3 so that it does not touch the leading tablet but deflects the following tablet which is found to be defective.

According to Figure 2 the press force is measured by a strain gauge measuring instrument 10 using strain gauges. The strain gauge measuring place is followed by a measuring amplifier 11 which can be constructed as a carrier frequency amplifier or d.c. amplifier. The measured press force is transferred by the measuring amplifier 11 to an electronic logic module 12 which is constructed as a press force monitoring unit. the said mdule 12 which is constructed as a press force monitoring unit. The said module 12 electronically processes the received press force signals by comparison with two adjustable set point limits. Evaluation in the logic module 12 takes place if the press force monitoring unit 12 receives a signal from a first punch proximity switch 13 to the effect that the maximum press force has been reached. The first punch proximity switch 13 therefore defines the precise time at which the maximum press force occurs, referred to each measured individual press force value. In addition it is a function of the said first punch proximity switch 13 to provide a shift register 14, also connected downstream of the press force monitoring unit 12, with the time or with a signal indicating when a new shifting cycle is to be performed. The shift register 14 transfers a signal to an electronic time processing element 16 to which a second punch proximity switch 15 is also connected. The signal which defines the precise commencement of time processing and the duration of delay for the transfer of the signal is fed to the time processing element 16 *via* the second punch proximity switch 15. The delay duration depends on the press forming frequency or on the rotational speed of the die plate.

The second punch proximity switch 15 can be constructed so that on reaching a predefined distance from an approaching punch it commences to deliver a signal until the relevant passing punch has reached a predefined distance. The duration of the signal is therefore dependent on the circumferential speed of the die plate or the rotational speed of the punch. If the signal is prolonged it follows that the tablet forming machine operates slowly. In this case the value of the quantity "X", to be explained subsequently, will be greater. In a practical application of an exemplified embodiment the said "X" was arranged to be three times as long as the signal delivered by the second punch proximity switch 15. This was done in order to obtain a more favourable ratio to the quantity "W", i.e. the delay time of the ejector device, which is relatively short. It should be noted that the so-called damping time, i.e. the duration of the signal delivered by the proximity switch 15, can be even shorter in practice than the quantity "W". However, since the quantity "X" must be greater than the quantity W it was decided to select the quantity X to be three times the length of the signal duration of the proximity switch 15. Such trebling of the time is not necessary if the machine operates relatively slowly because in such cases the damping time or signal duration of the switch 15 is long. On the one hand the signals of the second proximity switch 15 and on the other hand the signals of the shift register 14 are fed into the time process element. These two signals are processed in the time processing element 16 so that it delivers a signal at time C to the lifting magnet 8 for the operation thereof after prior amplification *via* a power amplifier 17.

The inter-relation between the various times is shown in the graph according to Figure 3 in which:

A = trigger time for the time processing electronic element 16.

B = time of reaching the grading position of the guide wall 7.

C = time of triggering for the lifting magnet 8.

X = delay depending on the press forming frequency or rotational speed (inversely proportional), the output value of which can be freely selected within specific limits.

W = time of motion or inertia time of the ejector device (7, 8) = 5 ms = constant.

Y = X − W (time from A to C).

Where X depends on:

$$X = \frac{F \, . \, S}{D . \pi . \dfrac{\text{Rev.}}{s}}$$

Where:

S = selected part of a punch pitch mm, for example damping distance of an initiator (15) triggered by a punch

F = multiplier, for example 3 = time and magnification factor

D = diameter (punch pitch circle) [mm]

$\dfrac{\text{Rev.}}{s}$ = rotor rotations/s.

The equation above reveals the proportion of dependence of the delay X on the punch pitch, on the punch pitch circle diameter and on the rotational speed, so that the punch pitch and pitch circle diameter which can be selected in steps are constant in individual presses so that the

rotational speed is the only variable. It also follows that the value of the quantity X will be smaller the greater the rotational speed.

The formula also reveals that the rotational speed, a time increase factor (S) and the inertia time (W) of the ejector device must be processed in the electronic time processing device. In the exemplified embodiment the rotational speed is continuously measured *via* the second proximity switch 15 whose damping time ($\frac{1}{3}$ times X) is a measure of the rotational speed of the die plate. Within the above-mentioned damping time, the pulses generated by an oscillator are counted into a counting register. Downward counting at a third of the counting frequency is performed during forward counting and beyond. Position 0 in the counting register would therefore be reached after a time corresponding to three times the damping time. As already indicated the ejector device 7, 8 must be triggered earlier by the amount of the inertia time. The value of W must therefore be subtracted from the trebled damping time. In the above-mentioned example the ejector device 7, 8 is not triggered when the zero position of the counting register is reached but at a number which is preselected with coding switches and corresponds to the inertia time of the grading element. Once the ejector device 7, 8 has been set to the ejector position UT it remains in this position until the next good tablet arrives. Time processing in dependence on rotational speed is necessary for the output motion of the guide wall 7 from the ejector position (UT) into the good position (OT) because the mass inertia of the ejector device must also be taken into account in this case. The rotational speed is then defined again as already described. The inertia time (W) of the ejector device is subtracted but because of the logic function the trigger pulse is used to move the ejector device from its ejector position (UT) into good position (OT).

The lifting magnet 9 for operating the guide wall 7 as part of the ejector device is a polarized bistable lifting magnet with two fixed positions for the armature obtained by the use of two permanent magnets which retain the armature in one or the other position. To this end the armature is slidably guided in a coil between the two permanent magnets. Energization of the coil causes the armature to be drawn into the limiting position where it is retained by the permanent magnet. The armature entrains the guide walls 7 *via* the piston rod 8. On polarity being reversed the armature is drawn into its other limiting position where it is retained by the other permanent magnet.

To reduce its mass, the guide plate 7 shown in Figure 5 consists of titanium and is provided with a bead 19 for stiffening purposes and with apertures 20.

Differences in the timed operation of the ejector device 7, 8 in dependence on different rotational speeds of the die plate are shown diagrammatically in Figure 4. In the case I in which the die plate rotates at a high rotational speed V_1 the guide plate 7 is already lowered at the time Z_1 at which time the advancing tablet C is still situated beneath the guide wall 7.

Commencement of raising Z_2 takes place after the succeeding tablet B, which has since been deflected, or its die has reached the guide wall 7. In the case II in which the rotational speed V_2 is substantially lower the guide plate 7 is lowered at a tie Z_1 at which the advancing tablet C has already passed far beyond the plane of the guide wall 7. Raising at the time Z_2 in this case II takes place after the die of the tablet B, which has been rejected as being poor, has already passed substantially beneath the plane of the guide wall. Low operating speeds or press forming frequencies in accordance with II is therefore accompanied by a delay in the operation of the ejector device since lowering and raising of the guide wall 7 always occupies the same amount of time. On the other hand, in the case II the dwell time is longer than at high operating speeds. This feature avoids complete absence in the deflection of the tablet if the die plate rotates at an extremely low speed. The novelty of the invention is therefore also to be seen in the shift of the commencement of the dwell time to its end in dependence on the rotational speed as explained by reference to examples I and II which also reveal that in the system according to the invention the trigger point of the magnet is advanced for high operating speeds or triggering is generally timed in dependence on the rotational speed of the die plate by reference to the position of a die which is passing through.

CLAIMS

1. A method of grading tablets, after the production thereof by press forming in the dies of a tablet forming machine, by measurement of the individual press forces, in which method an ejector station, disposed downstream of the press station, is actuated by control *via* a punch proximity switch in dependence on the measured individual press force, the ejector device being additionally controlled *via* a second punch proximity switch and an electronic time processing element in dependence, with respect to time, on the rotational speed of the die plate and on the position of a die relative to the ejector device.

2. A method according to claim 1, characterised in that the duration of an operating cycle of the ejector device is controlled in dependence on the rotational speed of the die plate.

3. A method according to claim 1 or claim 2, characterised in that the tablets are deflected from the die plate by lowering of a guide plate which is associated with an electromagnet.

4. Apparatus for grading tablets after the production thereof by press forming in dies of a tablet forming machine, the apparatus comprising a press force monitoring apparatus which, together with a first punch proximity switch, controls an ejector device *via* a shift register, a second punch proximity switch and an electronic

time processing element by means of which the ejector device can be controlled, in time dependence, relative to the rotational speed of the die plate and with respect to the position of a die relative to the ejector device.

5. Apparatus according to claim 4, characterised in that the ejector device is provided with a vertically adjustable guide wall.

6. Apparatus according to claim 5, characterised in that the guide wall is provided with a lifting magnet which can be actuated *via* the time processing element.

7. Apparatus according to claim 5 or claim 6, characterised in that the guide wall is provided with a piston which is associated with the armature of the lifting magnet.

8. Apparatus according to any one of claims 5 to 7, characterised in that the guide wall consists of titanium.

9. Apparatus according to any one of claims 5 to 8, characterised in that the guide wall is provided with a bead.

10. Apparatus according to any one of claims 5 to 9, characterised in that the guide wall is provided with apertures.

11. Apparatus for grading tablets, substantially as herein described, with reference to the accompanying drawings.

12. A method of grading tablets, substantially as herein described with reference to the accompanying drawings.

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